provided by dentists. Other workers who make medical devices include arch-support technicians, orthotics technicians (braces and surgical supports), prosthetics technicians (artificial limbs and appliances), opticians, and ophthalmic laboratory technicians.

Sources of Additional Information

For a list of accredited programs in dental laboratory technology, contact:

☛ Commission on Dental Accreditation, American Dental Association, 211 E. Chicago Ave., Chicago, IL 60611. Internet: **http://www.ada.org**

General information on grants and scholarships is available from dental technology schools.

For information on requirements for certification, contact:

☛ National Board for Certification in Dental Technology, 8201 Greensboro Dr., Suite 300, McLean VA 22101.

For information on career opportunities in commercial laboratories, contact:

☛ National Association of Dental Laboratories, 8201 Greensboro Dr., Suite 300, McLean VA 22101. Internet: **http://www.nadl.org**

Electronic Semiconductor Processors

(O*NET 92902A, 92902B, 92902C, 92902D, 92902E, and 92902G)

Significant Points

- Electronic semiconductor processors is the only manufacturing occupation expected to grow much faster than the average for all occupations.
- A 1-year certificate in semiconductor technology is good preparation for semiconductor processor operator positions; for more highly skilled technician positions, an associate degree in electronics technology or a related field is necessary.

Nature of the Work

Semiconductors—also known as computer chips, microchips, or integrated chips—are the miniature but powerful brains of high technology equipment. They are comprised of a myriad of tiny aluminum wires and electric switches, which manipulate the flow of electrical current. Electronic semiconductor processors are responsible for many of the steps necessary to manufacture each semiconductor that goes into a personal computer, missile guidance system, and a host of other electronic equipment.

Semiconductor processors manufacture semiconductors in disks about the size of dinner plates. These disks, called wafers, are thin slices of silicon on which the circuitry of the microchips is layered. Each wafer is eventually cut into dozens of individual chips.

Semiconductor processors make wafers using photolithography, a printing process for creating plates from photographic images. Operating automated equipment, workers imprint precise microscopic patterns of the circuitry on the wafers, etch out the patterns with acids, and replace the patterns with silicon and other materials. Then the wafers receive a chemical bath to make them smooth, and the imprint process begins again on a new layer with the next pattern. Wafers usually have from 8 to 20 such layers of microscopic, three-dimensional circuitry.

Semiconductors are produced in semiconductor fabricating plants, or "fabs". Within fabs, the manufacture and cutting of wafers to create semiconductors takes place in "clean rooms." Clean rooms are production areas that must be kept free of any airborne matter, because the least bit of dust can damage a semiconductor. All semiconductor processors working in clean rooms—both operators and technicians—must wear special lightweight outer garments known as "bunny suits." Bunny suits fit over clothing to prevent lint and other particles from contaminating semiconductor processing worksites.

Operators, who make up the majority of the workers in clean rooms, start and monitor the sophisticated equipment that performs the various tasks during the many steps of the semiconductor production sequence. They spend a great deal of time at computer terminals, monitoring the equipment. They transfer wafer carriers from one development station to the next. Once begun, production of semiconductor wafers is continuous: Operators work to the pace of the machinery that has largely automated the production process. Operators are responsible for keeping the automated machinery at proper operating parameters.

Technicians account for a smaller percentage of the workers in clean rooms, but they trouble-shoot production problems and make equipment adjustments and repairs. They also take the lead in assuring quality control and in maintaining equipment. In order to prevent the need for repairs, technicians perform diagnostic analyses and run computations. For example, technicians may determine if a flaw in a chip is due to contamination and peculiar to that wafer, or if the flaw is inherent in the manufacturing process.

Working Conditions

The work pace in clean rooms is deliberately slow. Limited movement keeps the air in clean rooms as free as possible of dust and other particles, which can destroy semiconductors during production. Because the machinery sets operators' rate of work in the largely automated production process, workers keep an easy-going pace. Although workers spend some time alone monitoring equipment, operators and technicians spend much of their time working in teams.

Technicians are on their feet most of the day, walking through the clean room to oversee production activities. Operators spend a great deal of time sitting or standing at work stations, monitoring computer readouts and gauges. Sometimes, they must retrieve wafers from one station and take them to another. To minimize the risk of dropping expensive wafers and semiconductors, transportation of wafer carriers between work stations is usually automated.

The temperature in the clean rooms must be kept within narrow ranges, usually a comfortable 72 degrees Fahrenheit. The temperature inside bunny suits stays fairly constant as well. However, workers in bunny suits face some restrictions because entry and exit from each clean room are controlled to minimize contamination.

An electronic semiconductor processor inspects the quality of the wafers containing microchips.

The work environment of semiconductor fabricating plants is one of the safest in any industry. Measures taken to avoid contamination of the wafers lead to more than just antiseptically clean rooms: they result in a work environment nearly free of conditions that cause occupational illnesses and accidents.

Semiconductor fabricating plants operate around the clock. For this reason, night and weekend work is common. In some plants, workers maintain standard 8-hour shifts, 5 days a week. In other plants, employees work 12-hour shifts to minimize the disruption of clean room operations brought about by shift changes. Managers in some plants allow workers to alternate schedules for equitable distribution of the "graveyard" shift.

Employment

Electronic semiconductor processors held 63,000 jobs in 1998. Nearly all of them were employed in facilities that manufacture electronic components and accessories, though a small percentage worked in plants that primarily manufacture computers and office equipment.

Training, Other Qualifications, and Advancement

People interested in becoming semiconductor processors, either operators or technicians, need a solid background in mathematics and physical sciences. In addition to their application to the field, math and science knowledge are essentials for pursuing higher education in semiconductor technology—and knowledge of both subjects is one of the best ways to advance in the semiconductor fabricating field.

Semiconductor processor workers must also be able to think analytically and critically to anticipate problems and avoid costly mistakes. Communication skills are also vital, as workers must be able to convey their thoughts and ideas both orally and in writing.

A high school diploma or equivalent is the minimum requirement for entry-level operator jobs in semiconductor fabrication plants. Technicians must have at least an associate degree in electronics technology or a related field. Although completion of a 1-year certificate program in semiconductor technology offered by some community colleges is an asset, employers prefer to hire persons who have completed associate degree programs.

Degree or certificate candidates who get hands-on training while attending school look even more attractive to prospective employers. Semiconductor technology programs in a growing number of community colleges include an internship at a semiconductor fabricating plant; many students in these programs already hold full- or part-time jobs in the industry and work toward semiconductor technology in their spare time to upgrade or update their skills. In addition, to ensure that operators and technicians keep their skills current, most employers provide 40 hours of formal training annually. Some employers also provide financial assistance to employees who want to earn associate and bachelor's degrees.

Those who live near a semiconductor processing plant may have another option for getting started in the field: summer and part-time employment. Students often are hired to work during the summer, and some students are allowed to continue working part time during the school year. Students in summer and part-time semiconductor processor jobs learn what education they need to prosper in the field. They also gain valuable experience that may lead to full-time employment after graduation.

Some semiconductor processing technicians transfer to sales engineer jobs with suppliers of the machines that manufacture the semiconductors or become field support personnel.

Job Outlook

Between 1998 and 2008, employment of electronic semiconductor processors is projected to increase much faster than the average for all occupations. Besides the creation of new jobs, additional openings will result from the need to replace workers who leave the occupation. Growing demand for semiconductors and semiconductor processors will stem from the many existing and future applications for semiconductors in computers, vehicles, telecommunications, appliances, and other equipment.

The electronic components and accessories industry is projected to be one of the most rapidly growing manufacturing industries. Moreover, industry development of semiconductors made from better materials means that semiconductors will become even smaller, more powerful, and more durable. For example, the industry is researching a new generation of microchips, made with copper rather than aluminum wires, which will better conduct electricity. Also, technology to develop chips based on plastic, rather than on silicon, will make laptop computers durable enough to take to worksites where these computers could not easily have been used previously, such as construction sites. These technological developments will lead to new applications in commercial markets, resulting in employment growth in the industry.

Job prospects should be best for people with postsecondary education in electronics or semiconductor technology. Prospects should also be favorable for high school graduates with a strong science background, particularly for those who are willing to work toward a postsecondary degree while employed.

Earnings

Median hourly earnings of electronic semiconductor processors were $11.93 in 1998. The middle 50 percent earned between $9.76 and $14.25 an hour. The lowest 10 percent earned less than $8.43 and the top 10 percent earned more than $17.70 an hour.

Technicians with an associate degree in electronics or semiconductor technology generally started at higher salaries than those with less education.

Related Occupations

Electronic semiconductor processors do production work that resembles the work of precision assemblers of electrical and electronic equipment. Also, many electronic semiconductor processors have academic training in semiconductor technology, which emphasizes scientific and engineering principles. Other occupations that require some college or postsecondary vocational training emphasizing such principles are electrical and electronic technicians and science technicians.

Sources of Additional Information

For more information on semiconductor processor careers, contact:

☛ Semiconductor Industry Association, 4300 Stevens Creek Blvd., No. 271, San Jose, CA 95129.

☛ SEMATECH, 2706 Montopolis Dr., Austin, TX 78741. Internet: **http://www.4chipjobs.com**

☛ Maricopa Advanced Technology Education Center (MATEC), 2323 West 14th St., Suite 402, Tempe, AZ 85281. Internet: **http://matec.org**

Ophthalmic Laboratory Technicians

(O*NET 89917A and 89917D)

Significant Points

- Although some lenses are still produced by hand, technicians increasingly use automated equipment to make lenses.
- Nearly all ophthalmic laboratory technicians learn their skills on the job.
- The number of job openings will be low because the occupation is small and slow growth in employment is expected.

Nature of the Work

Ophthalmic laboratory technicians—also known as manufacturing opticians, optical mechanics, or optical goods workers—make prescription